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THE CARDIOVASCULAR RESPONSE TO THE AGS

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INTRODUCTION

An instrument, the AGS (artificial gravity simulator), has been built to produce artificial gravity. This paper reports preliminary results of experiments on human subjects conducted to study the cardiovascular response to various g-levels and exposure times.

METHODS

The design and construction of the AGS has been described in previous papers[2]. Very briefly, the AGS may be classified as a short arm centrifuge. It consists of a turntable, a traction system, a platform and four beds.

Through a communications system, test subjects and observers are in constant contact by voice telemetry. Subjects can be observed through video cameras installed on the canopies covering the beds, although this feature has not been used yet.

A custom designed data collection hardware is part of the communications system. A multiplexer, under computer control, directs the sequential collection of data from each of the four subjects and transmits the data signals to appropriate measuring devices located on the AGS platform. The multiplexer receives the signals from each measuring device, transmits them to twelve slip rings on the centrifuge shaft and, through cables, to a computer for data analysis, storage and display.

The instrumentation used to record the cardiovascular response is based on electrical impedance and manometric techniques which have been also previously described[4].

The AGS produces a steep acceleration gradient. Due to the scarcity of data available from experiments conducted with instruments producing steep gradients it became necessary to carry out experiments to document the cardiovascular response to the AGS.

The experiments were conducted with subjects in the supine position, head close to the axis of rotation of the AGS and feet in the periphery. The experiments lasted for 30 to 60 minutes at the following g-levels at the feet (17 rpm $\simeq$ 0.75 g; 20 rpm $\simeq$ 1.0 g; 22 rpm $\simeq$ 1.25 g; and 24 rpm $\simeq$ 1.5 g.) The 30 or 60 minute rotation was preceded by 30 minute rest and followed by another 30 minute recovery.

RESULTS

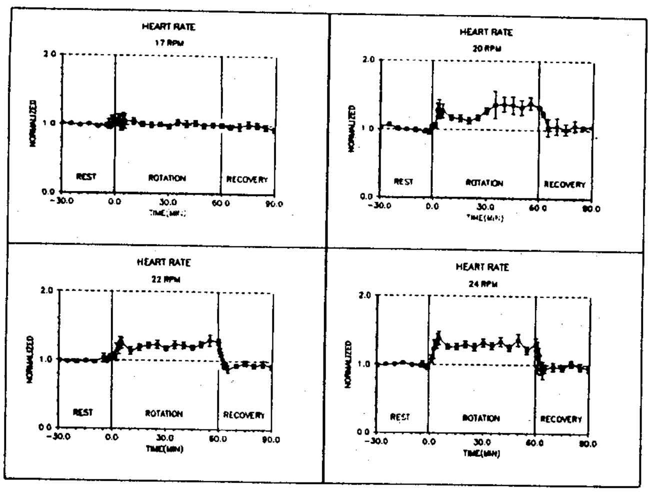
The cardiovascular response was studied by monitoring continuously the following variables: TFI (thoracic electrical impedance); SV (stroke volume); HR (heart rate); CO (cardiac output); EVI (ejection velocity index); SBP (systolic blood pressure); and (DBP (diastolic blood pressure).

The mean and standard error of each of these variables are displayed graphically in the following panels. The data for the thirty minute experiments were combined with the one-hour experiments.

The mean and standard errors shown in the graphs were obtained on six subjects in all the experiments except in the 20 rpm 60 min. experiment in which only three subjects participated. This may explain the larger variation reflected in the 20 rpm graphs. The subjects were all males (age 24 $\pm$ 0.9 yr., weight 77.9 $\pm$ 3.5 kg., height 181.5 $\pm$ 2.6 cm.)

Although the data have been only partially analyzed, there is little doubt that there is a consistent response to the AGS. There is an increase in the thoracic impedance (TFI) which is interpreted as fluid leaving the thorax towards the lower extremities. There is a drop in stroke volume (SV) and a simultaneous increase in heart rate (HR) so that cardiac output (CO) is only partially compensated, particularly at the higher g-levels. The ejection velocity (EVI) probably changes insignificantly up to 24 rpm (approximately 1.5 g). The systolic blood pressure (SBP) is maintained at the pre-rotation level, whereas the diastolic blood pressure (DBP) increases.

Mean ± S.E.



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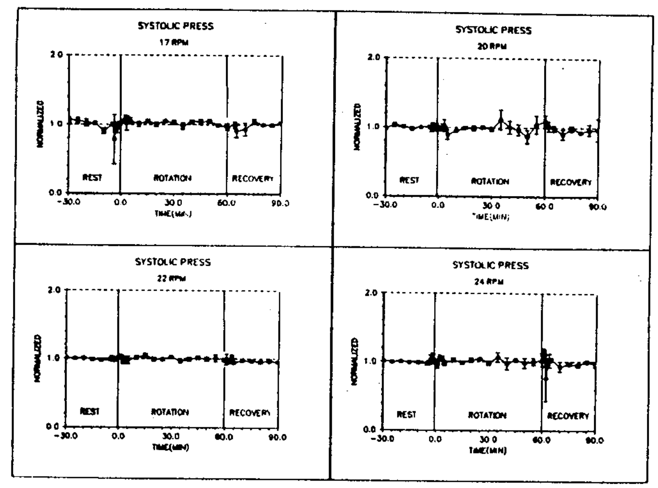

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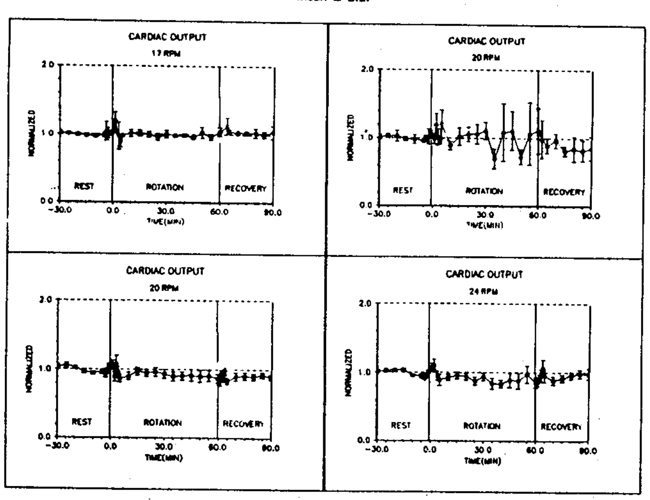

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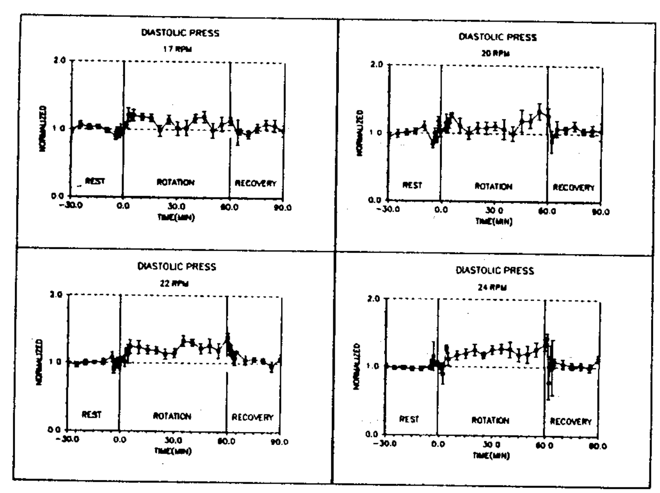

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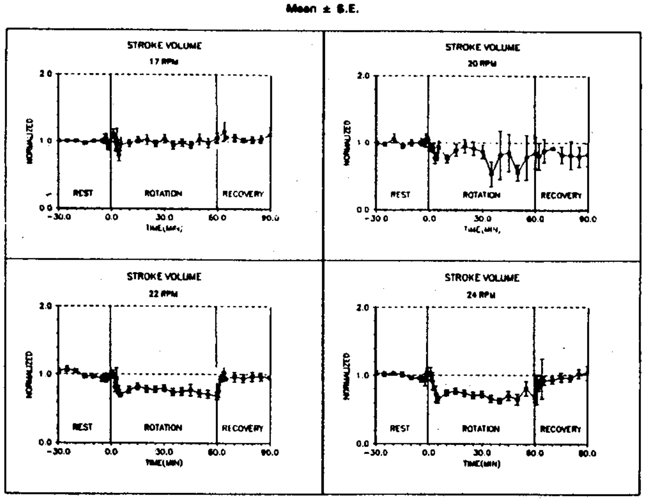

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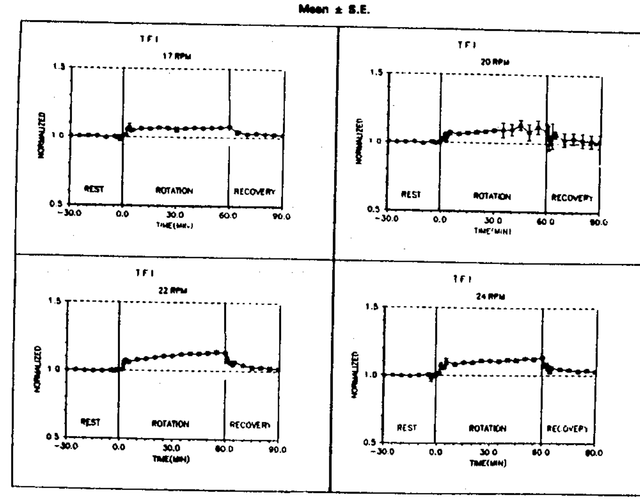

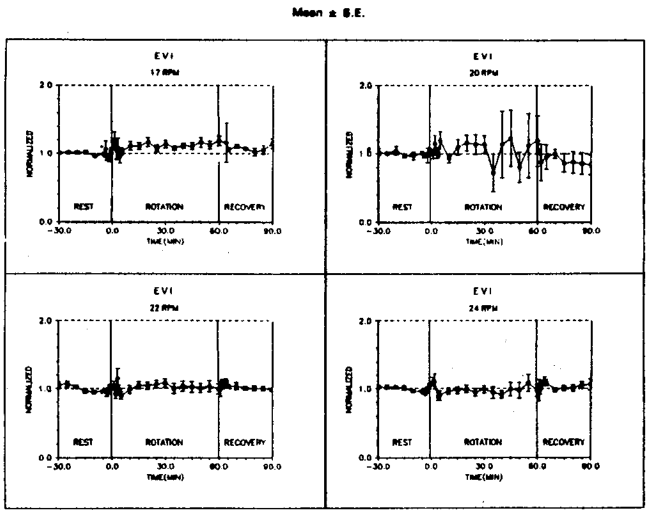

DISCUSSION

Previous work done by others [1,3,5,6] suggests very strongly that artificial gravity may play a role in space, but more physiological data are necessary to justify specific recommendations for inflight experiments. The fluid transfer and cardiovascular response of the AGS is qualitatively the same as that of the head-up tilt (HUT). We believe that changes in posture are the natural stimulus that maintains the system that regulates the effects of such postural changes in a state of readiness for optimal function. Humans spend one-third of the day in the horizontal position and two-thirds sitting or standing. This habitual alternance in posture constitutes the gymnastics of the cardiovascular system that prevents orthostatic intolerance within physiological limits, the same as exercise maintains good muscular tone.

Because the AGS produces the same cardiovascular effects as the habitual postural changes the application of artificial gravity with an apparatus similar to the AGS may be effective as a countermeasure of the cardiovascular deconditioning that occurs in the space environment. Our future research is aimed at proving this hypothesis.

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